

Surveys of harvest technology of winter bamboo shoots

LIU Tian-hu

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Abstract: Winter bamboo shoots are widely used in Asian cuisine. We surveyed growth depth (tail depth and root depth), harvest speed, and harvest processes to provide information for developing new harvest technology. The tail depth of most winter bamboo shoots was 100–350 mm below the soil surface, and the root depth was 200–500 mm below the soil surface. Most winter bamboo shoots were difficult to locate with only the naked eye. The digging depth was 200–500 mm to cut winter bamboo shoots from the root. The highest harvest rate was 7.75 times faster than the slowest one and the average harvest speed ratio of men: women was about 1.71:1. The harvest process of winter bamboo shoots was divisible into three steps: searching, digging a hole (around the shoot) and cutting the root. The ratio of searching time to the sum of digging and cutting time was about 8:1, showing that searching required more time than digging and cutting together.

Keywords: winter shoots; *Phyllostachys pubescens*; harvest; survey

Introduction

Bamboos are large, woody grasses growing in tropical and subtropical regions, covering wide areas of Asia, Africa, the Caribbean, and Latin America (Lu et al. 2005). More than 1250 species of 75 genera are reported worldwide. Bamboo forests in China cover about 4.846 million ha (<http://www.chinaforestry.com.cn/zxzx/view.aspx?id=2207>, 2005).

Bamboo shoots are the tender, young offspring of bamboo.

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LIU Tian-hu

College of Engineering, South China Agricultural University, 483 Wushan street, Guangzhou, 510643, China.

E-mail: liuparalake@126.com

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They contain large quantities of dietary fiber, consisting of approximately 8% soluble fiber and 92% insoluble fiber. Most dietary fiber in bamboo shoots consists of hemicellulose, cellulose, pectin, and lignin (Fuchigami 1990). Bamboo shoots are widely used as vegetables in Asian cooking. Among bamboo shoot products, fresh shoots are far superior in taste and texture (Zhu et al. 1994). Analyses of the nutritive value of bamboo shoots were reported by several researchers (Bhatt et al. 2003 and 2005; Park et al. 2009; Satya et al. 2010). About 2.17 million tons of fresh bamboo shoots are produced annually in China (Li et al. 2001). Trade in bamboo shoots and their rattan products are estimated to be worth at least US\$ 5 billion annually (Franklin 2006). Among bamboo shoots, the main source is *Phyllostachys pubescens*. In Japan more than 8000 tons of bamboo shoots are consumed every year and the main source is *P. pubescens* (Satya et al. 2010).

There are two types of shoots of *P. pubescens*, winter and spring bamboo shoots. Winter shoots grow from lateral buds of *P. pubescens* underground stems (rhizomes) at the beginning of autumn. Most do not grow into bamboo but rot in the coming year. But from November to February many winter bamboo shoots grow to 250–750 g, which is a marketable weight.

During the harvest, winter bamboo shoots are cut below the soil surface with a spade or hoe. There are no published reports on the harvest of winter bamboo shoots, and no systematic investigation of advanced harvest methods for winter bamboo shoots. In recent years, we visited farmers living on bamboo products in Guangdong, Jiangxi, Hunan and Fujian Provinces, China, and found that more 90% of farmers used hoes, while less than 10% used narrow spades or sharp pestles to harvest winter bamboo shoots. These tools lag behind the best available technology.

To provide information for developing new harvest tools, we undertook surveys of winter bamboo shoots and harvest methods during the 2007–2008 and 2009–2010 harvest seasons. The survey information included growth depth (tail depth and root depth), harvest rate, and harvest method. The objectives of these surveys were to identify the digging depth of harvest works, describe harvest methods, and characterize the harvest process.

Methods

All surveys were carried out at Wuzhifeng township, Shangyou County, Jiangxi, China, where the bamboo of *P. pubescens* is the most important resource, and the winter bamboo shoots are produced, consumed, processed, and traded.

Growing depth

This survey was conducted in January, 2008. The elevation of sampling region was 300–800 m. We divided the sampling region into five sub-regions according to elevation: 300–400 m, 400–500 m, 500–600 m, 600–700 m, and 700–800 m. Each sub-region was further divided into four sampling points: valley, 1:3 slope, 2:3 slope, and ridge. We searched for winter bamboo shoots, removed half of the soil around each shoot, then measured root depth and tail depth (Fig. 1). About 10 samples were measured at each sampling point.

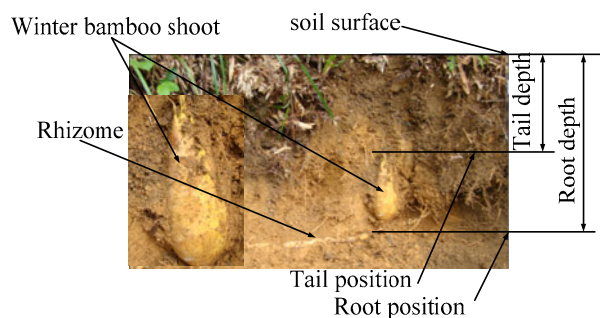


Fig. 1 Tail depth and root depth

Harvest speed

This survey was conducted during the 2007–2008 and 2009–2010 harvest seasons. Three hundreds of farmers in three villages were selected for survey. The selected farmers were divided into three groups according to their home village. Each group was further divided into 10 subgroups based on farmer age (Table 1). During each survey period the working hours were set as 7:30–11:30 am and 1:00–5:00 pm. Daily output was measured at 6:00 pm. We weighed shoots by a steelyard with the accuracy of 0.1 kg. The daily average output of 10 successive normal harvest days was taken as a farmer's harvest speed ($\text{kg} \cdot \text{d}^{-1}$).

Course of harvest process

Local folklore notes: “No findings, no harvest”. Searching is a key step in the harvest of winter bamboo shoots. The proportion of total harvest time accounted for by searching remains unclear. The present investigation was carried out in January 2008. We randomly selected five farmers, and randomly recorded their process of harvesting six winter bamboo shoots.

Table 1. Further grouping scheme according to age of harvester

Subgroup No.	Age range	Subgroup No.	Age range
1	15-20	6	41-45
2	21-25	7	46-50
3	26-30	8	51-55
4	31-35	9	56-60
5	36-40	10	61-65

Results

Growing depth

Fig. 2(a) shows the distribution chart of tail depth, while Fig. 2(b) shows the distribution chart of root depth. Fig. 2(a) shows that only a small percentage of winter bamboo shoots grow out the soil surface (tail depth less than 0 mm) and tail depth of most winter bamboo shoots was 100–350 mm. Accordingly, most shoots were difficult to locate with only the naked eye. Fig. 2(b) demonstrates that root depth of most winter bamboo shoots was 200–500 mm. Therefore, in general, the digging depth should be 200–500 mm for cutting the winter bamboo shoots from the root.

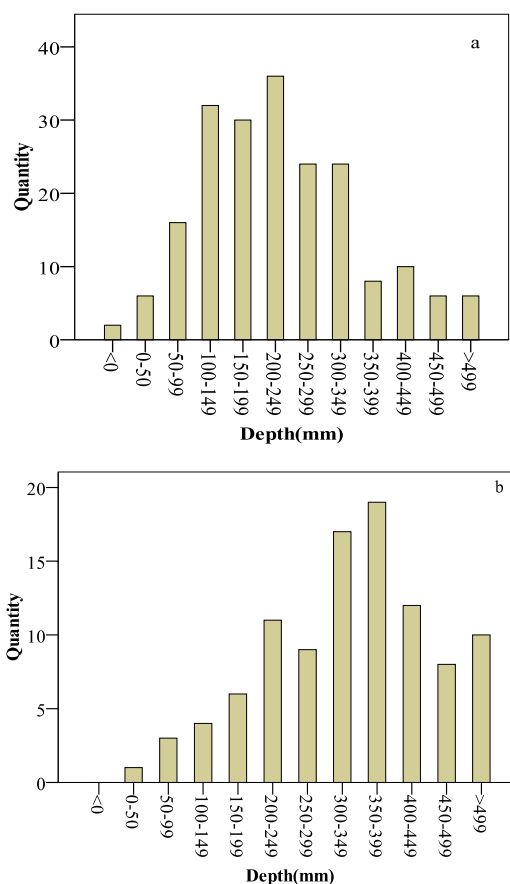


Fig. 2 Distribution chart of tail depth (a) and root depth (b)

Harvest speed

As shown in Tables 2 and 3 the average harvest speeds in

2009–2010 and 2007–2008 harvest season were $8.13 \text{ kg}\cdot\text{d}^{-1}$ and $7.15 \text{ kg}\cdot\text{d}^{-1}$, respectively. The slowest harvest rate was $2.0 \text{ kg}\cdot\text{d}^{-1}$, while the fastest harvest rate was $15.5 \text{ kg}\cdot\text{d}^{-1}$. The fastest harvest rate was 7.75 times the slowest. It shows an obvious difference in harvest rate among farmers. The average harvest rates for men and women were $9.63 \text{ kg}\cdot\text{d}^{-1}$ and $5.64 \text{ kg}\cdot\text{d}^{-1}$, respectively. The ratio of the average harvest rate of men:women was about 1.71:1. Therefore, average harvest rate for men was higher than that of women.

Table 2. Harvest speed in January, 2008 ($\text{kg}\cdot\text{d}^{-1}$)

Subgroup No.	Village (group) No.1		Village (group) No.2		Village (group) No.3	
	Male	Female	Male	Female	Male	Female
1	4.0	2.0	4.8	2.8	5.8	3.5
2	7.0	5.5	7.0	3.8	8.2	3.2
3	10.0	5.8	10.0	6.5	11.9	7.5
4	10.0	7.5	9.8	7.0	13.5	7.3
5	10.2	7.3	9.5	6.5	13.0	8.0
6	10.5	7.6	10.2	5.5	10.0	6.7
7	10.5	6.0	9.8	6.0	9.5	5.9
8	9.0	6.5	9.2	4.9	8.3	5.9
9	8.5	5.5	8.5	3.9	7.2	4.5
10	5.0	3.5	7.5	3.5	7.2	3.5

Table 3. Harvest speed in January, 2010 ($\text{kg}\cdot\text{d}^{-1}$)

Subgroup No.	Village (group) No.1		Village (group) No.2		Village (group) No.3	
	Male	Female	Male	Female	Male	Female
1	4.5	2.5	5.5	3.5	6.0	4.2
2	7.8	4.5	7.9	4.0	8.2	3.7
3	11.8	6.7	10.8	7.2	12.5	7.5
4	12.8	8.0	10.5	6.8	13.9	8.2
5	12.6	8.2	10.9	7.2	13.5	7.9
6	15.5	8.0	13.2	5.0	15.5	6.5
7	13.0	7.0	12.5	6.5	15	7.0
8	9.5	7.0	10.5	5.2	9.8	5.7
9	9.5	6.0	10.0	4.5	8.5	4.2
10	6.0	3.5	8.0	4.0	7.8	4.3

The average harvest rate by age is shown in Fig. 3. From 15 to 30 years of age, the older farmers harvested at a faster rate because the older farmers were stronger, faster at search winter bamboo shoots, and more skillful. From 50 years old, the harvest rate slowed because farmer physical strength and visual acuity decreased at old age.

Course of harvest process

Regardless of farmer identity or skill, most harvest work included three basic steps: searching, digging a hole around the shoot, and cutting the root. But when shoots had many twigs

(tender roots), there would be a further hole digging step after cutting of the root was finished. All recorded root cutting steps took little time, most less than 10s. The time required for harvest is shown in Fig. 4.

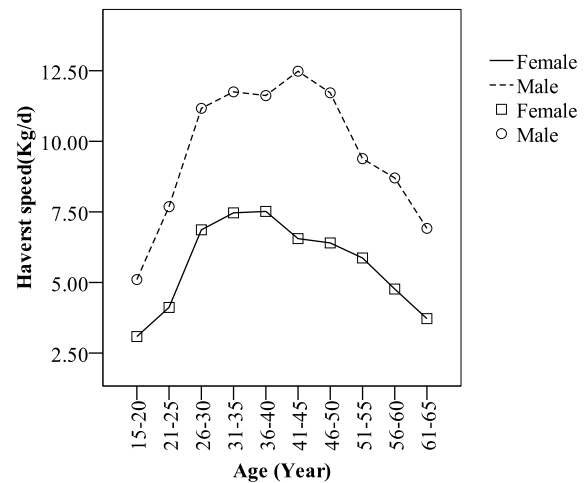


Fig. 3 Average harvest speed by age of harvester

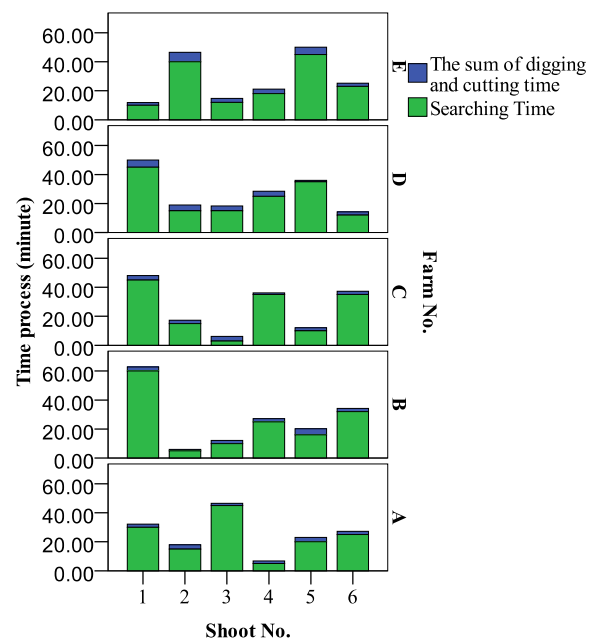


Fig. 4 Processing time of harvest work

The average time required for digging hole and cutting the root was 3 min. The shortest and longest times for digging hole and cutting the root were 1.0 min (B, #2) and 7.1 min (E, #2), respectively. Winter bamboo shoot (B, #2) grew out the soil surface. It weighed 0.12 kg and its root depth was only 10.0 mm. The shortest and longest searching times were 3.0 min (C, #3) and 60 min (B, #1), respectively. The average searching time was 24.2 min. The shortest and longest harvest times were 6.1 min (C, #3) and 62.8 min (B, #1), respectively. The average harvest time

was 27.2 min. The average ratio of searching time to the sum of digging and cutting time was 89:11 \approx 8:1 (Fig. 5), which indicates that most of the harvest time was spent searching for winter bamboo shoots.



Fig. 5. Pie chart of average ratio of searching time to the sum of digging and cutting time

Discussion

The survey area was located in Luoxiao Mountains, which is one of the main bamboo planting regions for *P. pubescens* in China. This investigation is therefore important for learning the characteristics of harvest technology of winter bamboo shoots. Fig. 3 reveals that the average harvest rate of men was higher than that for women. We found that the skill of women in harvesting winter bamboo shoots was not significantly lower than that of men. At present, the harvest work relies on physical labor closely.

As shown in Fig. 5, searching time was far greater than the sum of digging and cutting time. Most of the searching work consisted of digging along rhizomes or fully digging the soil, and then searching using naked eyes. This method is inefficient and tiring for the harvester. Traditional digging tools used at our study area were spades and hoes. If those tools are not improved, the only way to quicken digging rates is by enhancing the physical strength and stamina of harvesters, which is difficult to do. Mechanization and automation of digging tools is necessary. As the planting regions of bamboo of *P. pubescens* are rugged mountains, digging tools must be light, compact and efficient.

Conclusion

The tail depth of most winter bamboo shoots was 100–350 mm below the soil surface, and the root depth was 200–500 mm be-

low the soil surface. The values reflect that most winter bamboo shoots are hard to find only with naked eyes, and the digging depth usually should be 200–500mm to cut winter bamboo shoots from the root.

The fastest harvest rate was 7.75 times the slowest, and the ratio of the average harvest rate of men: women was about 1.71:1. The harvest rate thus differed among farmers and men harvested faster than women.

The harvest process of winter bamboo shoots was divisible into three steps: searching, digging a hole around the shoot, and cutting the root. The ratio of searching time to the sum of digging and cutting time was about 8:1.

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